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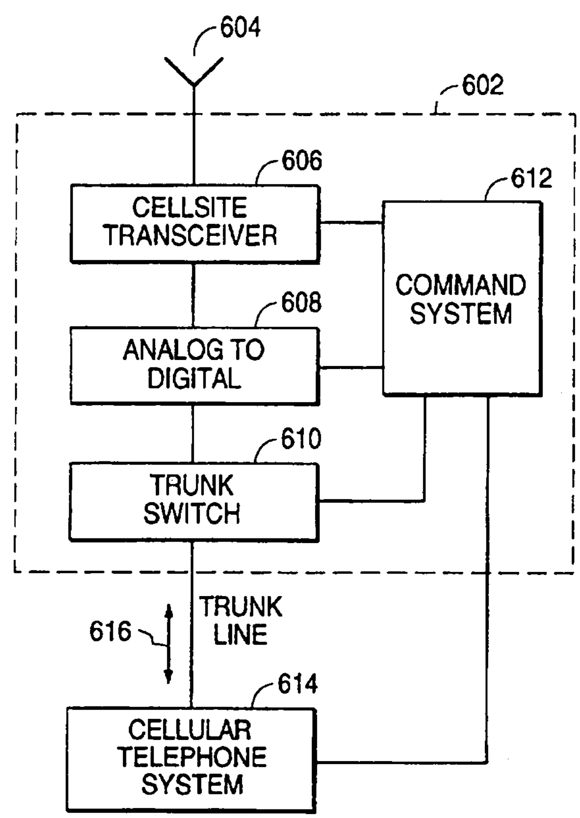
(54) Title: RADIO TELEPHONE SYSTEM USING VOICE/DATA SIGNAL

(57) Abstract

A method and apparatus differentiate between voice calls and data calls in a cellular telephone network. A data signal discriminator (612) at cellsites (602) to independently monitor cellular channels and detect the presence of modulated data, and generation of predetermined signals by a cellular modem or interface circuit, such as dialing string instructions, periodic tones or periodic dta patterns during call placement, which are detectable to identify data calls.



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"RADIO TELEPHONE SYSTEM USING VOICE/DATA SIGNAL".

Field of the Invention

The present invention relates to a method and an apparatus for automatically discriminating between voice and modulated data transmissions over a radiotelephone system, particularly to facilitate control operations of the radiotelephone system to provide differential treatment of data and voice calls.

Background of the Invention

Over the last decade, cellular radiotelephone systems have been introduced in most major population areas in the United States and cellular radiotelephone service is now widely available. These cellular systems were originally designed for voice communication, and in many respects were not well suited to digital data communications.

The well known early difficulties of transmitting modulated data over a cellular radiotelephone were first overcome when a practical cellular data modem was developed, through research by the assignee of the present application. An early cellular data modem is described in U.S. Patent 4,697,281 to O'Sullivan (now U.S. Patent RE 34,034), assigned to the assignee of the present application. Development of more advanced cellular modem systems continues, as exemplified by the systems disclosed in the original inventor's U.S. Patent No. 5,127,041, also owned by the assignee of the present application, and pending U.S. Patent application Serial No. 07/863,568, similarly assigned to the assignee of the present application.

Cellular ready modems, as distinguished from traditional landline modems, have particular protocol and operating characteristics that effectively compensate for adverse characteristics of the cellular radio environment. As examples, an extended delay before hangup on loss of carrier, packetized data transmission with dynamically adjustable packet sizes, and the use of forward error correction, have all been found to improve link quality and data throughput in cellular data communications. Such enhancements make it practical to transmit modulated computer or facsimile data through a cellular telephone.

Another radio data transmission system, the Cellular Digital Packet Data (CDPD) system, is under development by a number of large cellular carriers as a further part of the cellular radiotelephone network. This system is discussed in the "CDPD System Overview" dated May 22, 1992. The CDPD system uses cellular radio frequencies and operates with modems similar in most important respects to the cellular radiotelephone modems described above. It is expected that customers transmitting data over this system will be charged for each packet of data transmitted. Since only data is being transmitted, a simultaneously two-way communication link is not required. The CDPD system is less advantageous than the cellular telephone network for mobile data communications for several reasons. First, the CDPD system requires establishing a parallel cellular network, including costly additional transceiver and processing hardware to be installed at each cellsite where coverage is desired. The CDPD system requires a special subscription and special modem and transmitting equipment for transferring data packets; this special modem and transmitter are dedicated to this purpose, and are thus not useful for

any kind of telephone communications. In particular, the modem cannot be used with a standard telephone. Thus, the equipment package needed by each user is a relatively high-cost, limited market, dedicated purpose product. In contrast, a standardized, mass produced modem installed in a portable computer, such as the modems disclosed in U.S. Patent 5,127,041 and pending application Serial No. 07/863,568, can be used both for mobile and fixed data communications over a variety of telephone and other data networks. Such a modem can be used with the portable cellular transceiver already possessed by the user for making mobile voice calls, so no dedicated transceiver is needed. Since the planned CDPD packet radio system is dedicated to data transmission, it does not transmit voice signals, but is instead designed to record the number of packets transmitted for billing purposes.

Cellular radiotelephone systems are made up of a number of geographically dispersed cellsite transceivers, which are connected within a network, usually using standard T1 telephone trunk lines, to a mobile telephone switching office (MTSO) which is similarly connected to the local telephone central office (CO). These systems are generally designed to establish and maintain an analog communications channel between a cellular radiotelephone user in a cellsite area, and another telephone user anywhere in the world. Generally, radiotelephone service is provided on a metered basis. Various service plans are available, but typical cellular call charges during weekday business hours may be between 19 and 65 cents per minute.

Within their bandwidth and other limitations, the cellular channels convey any signals generated by parties to the link, without examining the particular character of the signals. Thus, there is presently no

means by which a cellular carrier could vary operation of the system depending on the sort of information conveyed by the customer over the cellular link.

Apparatus for discriminating between voice and data signals is known, although as far as the applicant is aware, such apparatus has not been used in conjunction with a cellular radiotelephone system to achieve the advantages provided by the present invention. U.S. Patent 5,073,921 to Nomura et al. shows an apparatus which distinguishes between voice and fax signals to control the connection of a facsimile machine to a telephone line. U.S. Patent 3,927,259 to Brown shows a system that identifies signals as either noise, modulated data, voice, or no signal based on analysis of repetition elements in the signals. This system may be used to control circuit switching in a telephone system.

Similarly, U.S. Patents 3,851,112 to Kusan, 5,095,534 to Hiyama, 5,081,673 to Engelke et al., 4,972,462 to Shibata, 4,955,083 to Phillips et al., 4,498,173 to Reudink, 4,403,322 to Kato et al., 4,376,310 to Stackhouse et al., 4,330,862 to Smolik, and 3,939,431 to Cohlman show circuits that carry and/or detect both voice and data signals.

U.S. Patent 4,654,867 to Labedz et al. discloses a cellular voice and data communications system which switches between data and voice formats in response to requests transmitted by user equipment. However, this system merely receives and responds to predetermined commands and does not provide any automatic data determination functions. In addition, Labedz does not disclose control of billing computers to provide differential service rates based on the type of transmission.

Persons transmitting computer or facsimile image data over cellular radiotelephones tend to be business

users who are willing to pay for mobile data communications services offering, alternatively, voice or data transmission capabilities. The inventor believes that some cellular data carriers may wish to charge a differential rate, or even a lower rate, for data transmission services. In addition, the inventor has determined that advantageous operation could be obtained by controlling calls differently depending on whether they are data or voice calls. For example, actions that may result in degraded data transmission performance could be delayed or avoided if it was known that the cellular channel was being used for data transmission. For these reasons, there is a need for a system and method for identifying cellular radiotelephone calls as modulated data transmission calls.

Summary of the Invention

Therefore, it is a general object of the present invention to provide a novel and unique method for discriminating between voice and modulated data transmissions over a radiotelephone system to facilitate differential treatment of data and voice calls.

Another general object of the present invention to provide novel and unique apparatus for discriminating between voice and modulated data transmissions over a radiotelephone system to facilitate differential treatment of data and voice calls.

Another object of the present invention is to provide a system and method to facilitate charging a differential rate for the transmission of data over a cellular radiotelephone link.

It is another object of the present invention to provide a system and method for identifying cellular

telephone calls as modulated data calls so that a modified call handling procedure can be followed with respect to such calls.

A further object of the present invention is to provide a system and method for detecting modulated data transmission over cellular radiotelephone channels to minimize cell handoffs of data calls which are not strictly necessitated by travel between cellsites.

These objects and others which will be apparent upon review of the specification and drawings, are achieved in the present invention by providing various methods and apparatus for differentiating between voice calls and calls in which data is transmitted. In a first preferred embodiment, data transmission detectors installed at the cellsite monitor cellular channels carrying calls and detects the presence of modulated data. The data transmission detectors are connected to the command channel network of the cellular system and indicate which channels are carrying modulated digital data. This information is then used by the cellular system for billing and call-control purposes.

In a second embodiment, a cellular compatible modem or an interface device connecting the modem to the cellular telephone transceiver generates predetermined dialing string instructions during call placement to inform the cellular carrier that the call being placed is a data call.

In a third embodiment, a cellular telephone user desiring to transmit data over a cellular telephone network can identify his call as a data call to allow the cellular system to activate special handling for the call.

In a fourth embodiment, periodic transmissions readily detectable by cellsite or MTSO switching equipment are inserted in the data stream transmitted by

a modem and their presence is used to activate special handling for the call.

The systems and methods disclosed permit charging a differential rate for the transmission of data over the cellular link. In addition, the provision of data transmission detection permits modifications in call handling. For example, a call identified by the cellular carrier as a data call can be given priority in avoiding cell handoffs not strictly necessitated by travel between cellsites.

Brief Description of the Drawings

Figure 1 is a flowchart of an embodiment of the process of the present invention in which modulated data is detected by analyzing signals on a channel within the cellular carrier system.

Figure 2 is a block schematic diagram of an apparatus for performing the process of Figure 1.

Figure 3 is a graphical depiction of the criteria used to select a reference level signal for use in performing the process of Figure 1.

Figure 4 is a block schematic diagram of the installation of the apparatus of Figure 2 at a cellular radiotelephone system cell site transceiver.

Figure 5 is a flowchart showing another embodiment of a process for identifying a call as a data call, in which a special predetermined dialing sequence is generated by user equipment and detected by the cellular carrier equipment.

Figure 6 is a block schematic diagram of a digital trunk-monitoring embodiment of the data/voice discrimination apparatus of the present invention.

Detailed Description of the Preferred Embodiments

Referring to Figures 1A and 1B, a flowchart of one embodiment of the process of the present invention in which modulated data is detected by analyzing signals on a channel within the cellular carrier system is shown.

The process is initiated at block 102. The first operation in this process is selecting a cellular channel to be analyzed, as shown in block 104. The channels to be analyzed are selected from the available channels at the location where the process is performed, and preferably include all the channels available at that location in which there is a possibility of data transmission. Typically, when the method is performed at a cellsite location, the channels analyzed include all of the voice channels operative at the cellsite. Preferably, a data detector may be provided for each channel, although in some instances a plurality of channels may be monitored in sequence by a single data detector. If a plurality of channels are to be analyzed, the channels may be selected sequentially or by some other suitable criteria. For example, if certain cell channels were frequently found to be used for data transmission, these channels may be analyzed on a priority basis.

Following the selection of a channel to be analyzed, if a separate apparatus is not provided for each channel, the selected channel is filtered in block 106. Specifically, the selected channel is high-pass filtered so that only frequencies above approximately 800 Hertz remain. This removes any telephone company call progress signals such as dial tones, busy, and ringback signals, as well as the most powerful voice frequency fundamentals from the monitored signal.

The filtered channel is then rectified in block 108. This rectification converts the signal from an alternating current, or AC, signal to a rectified or

chopped signal. The rectified signal is then filtered in block 110 by an integrating circuit to produce an integrated DC signal. The level of this slowly varying DC signal is a measure of the high frequency power level of the selected channel being monitored.

The slowly varying DC signal, or channel level signal, is then compared with a reference level signal in block 112. The reference level signal is selected based on empirical testing. The level is selected such that when a data transmission is present on the selected channel, the channel level associated with that data transmission will be greater than the reference level. Similarly, when the selected channel is carrying a voice signal, the channel level associated with the voice transmission will be lower than the reference level. The selection of this reference level is discussed in more detail below with reference to Figure 3.

If the comparison in block 114 between the channel level and the reference level indicates that the channel level is below the reference level, then control will return to block 104 so that the process will immediately select another channel to be analyzed. If the comparison in block 114 between the channel level and the reference level indicates that the channel level is above the reference level, then control is transferred to block 116.

Once it has been determined that the channel level is above the reference level, a timer is started in block 116. The process then continuously compares the channel level to the reference level as shown in block 118 and checks the elapsed time in block 120. If the channel level remains above the reference level for a predetermined time, for example seven seconds, the process alerts the cellular command network in block 122. In this situation, it has been determined that the

channel being analyzed contains a data transmission. If, however, the channel level drops below the reference level prior to the timer indicating the predetermined time period has passed, the process will return to select another channel to be analyzed in block 104. In this case, it has been determined that the cellular channel does not contain a data transmission.

The requirement that the high frequency power level be high throughout a predetermined time period before identifying the call as a data call provides a significant advantage, because this test tends to reduce false data call identifications which might otherwise result, for example, from a happened coincidence of monitoring and a brief high pitched voice transmission such as laughter or a shriek.

Figure 2 shows a block diagram of a data detector according to one embodiment of the present invention. As shown in Figure 2, a data detector 202 comprises high pass filter 204, rectifier and filter 206, comparator 208, and timer 210.

High pass filter 204 is preferably constructed as a multi-order operational amplifier circuit, with a cutoff frequency of 800 Hz. High pass filter 204 filters out any telephone company call progress signals such as dial tones, busy, and ringback signals, as well as voice frequency fundamentals. The input 212 of high pass filter 204 may be connected through a differential input interface to tip and ring lines of the circuit to be monitored. Alternatively, the input 212 of high pass filter 204 may be connected directly to an output (not shown) of a demodulator located at a cell processing location. Preferably, a separate data detector 202 may be provided for each communications channel to be monitored. However, the input 212 of high pass filter 204 can be optionally connected to a selecting device

213, which may be an electronic multiplexing circuit designed to sequentially provide inputs to data detector 202 from each of a selected set of communications channels at the site which are to be monitored.

Rectifier and filter 206 operates to convert an AC signal received from high pass filter 204 to a slowly varying DC signal representing the high frequency power level of the telephone signal. As shown, rectifier and filter 206 may consist in its simplest form of a diode 207 or other rectifying element(s) placed in series with the signal passing through rectifier and filter 206, and a capacitor 209 or equivalent integrating element(s) connected between the signal and ground.

Comparator 208 receives this power level signal and compares it to a fixed reference voltage V+ provided at comparator input 214. Comparator 208 is conventional and the output 216 of the comparator is a logic level indicating the relationship between the power level signal and the reference voltage V+. If the power level signal exceeds the reference voltage V+, the logic level output of the comparator goes high to indicate that the monitored signal appears to be a data signal rather than a voice signal. The voltage V+ at reference voltage input 214 to comparator 208 is adjusted based on empirical testing to produce reliable switching of comparator 208 at high frequency power signal levels experienced when a data modem is used to transmit information through the telephone line, while providing a low level output when voice signals are transmitted.

Timer 210 measures the time that the output of the comparator 208 has remained high, indicating a possible data signal. If the comparator output is continuously high for more than, for example, 6 to 7 seconds, the timer 210 times out and the timer output signal 218 can then be used as a definitive indication that a data call

is taking place. Data detector 202 is provided with an output 220 from timer 210 to indicate the presence of a data call on the monitored channel.

In response to output 220, the cellular carrier can take desired steps in response to the use of the line for data transmission. For example, the indication of a data call may be fed to a billing and call tracking computer of the cellular carrier to produce differential billing, either at a higher or a lower rate than is used for voice calls. Also, call handling functions may be varied for detected data calls as opposed to voice calls. For example, the cellular carrier may prioritize channels within a cell based on their current usage so that channels being used for voice are handed off in preference to channels used for data. Data calls may thus be given a higher priority to avoid handoffs unless absolutely necessary for system operation or because the incoming signal has weakened because of movement into an adjacent cell. In metropolitan areas, there are a large number of cellular telephone users and significant cell overlap exists. With the method of the present invention, once a data call is detected, the cellular telephone system can reduce handoffs of data calls which occur not because of distance from the transmitter, but because of the movement of other users into the area and resulting overloading of the cell. Where cells overlap significantly, the system may also be able to reduce the absolute number of handoffs experienced by a moving vehicle conducting a data call. The call could be handed off from a cell only when the user is in range of a more distant cell that is not adjacent to the first cell, producing one handoff, rather than handing off to the adjacent cell and then to the more distant cell for a total of two handoffs. Furthermore, certain cellular channels that may be more resistant to noise and other

outside interference could be assigned to calls that are known to be transmitting data. For example, if another radio network was generating an interfering signal at a frequency that overlapped with a cellular channel, that channel, although suitable for voice transmission, may be less suitable, and thus avoided, for data transmission. Also, channels could be established with differential bandwidth capabilities, with wider bandwidth channels being assigned based on the detection of a data call according to the present invention. Selecting one of these various forms of "premium" channels for data transmission would result in fewer data transmission errors and thus greater data transmission efficiency. Therefore, overall connect time and cost could be reduced.

If users are expected to end data use and continue a call as a voice call, timer 210 can also used to identify the end of the data use phase of the call. If after indicating a data call, timer 210 indicates that the comparator has subsequently produced a "low" output for more than, for example, 6-7 seconds, this could be used as an indication of the end of the data use phase. An extended time in a non-data mode is required to identify the end of a data phase since cellular handoffs can be expected to interrupt the data flow and cause the comparator output to go temporarily low, even though data transmission will resume after the handoff is completed. Thus, timer 210 operates to compensate for effects of handoffs in this manner.

The apparatus illustrated in Figure 2 has been described and illustrated in analog form for simplicity of understanding. However, it should be recognized that such apparatus may also be constructed using digital processing equipment. The circuit shown in Figure 2 could also be appropriately constructed using a digital

signal processing chip programmed to provide the described operations. In general, with the analog version of this circuit, it is desirable to minimize the number of channels to be monitored by each circuit since the time required for detecting data on each channel (up to seven seconds) means that a single circuit might miss some data transmissions if required to monitor a large number of channels. In a digital implementation of the circuit, it would be possible to increase the number of channels monitored with a single data detector.

In addition, it should be recognized that the apparatus disclosed could be implemented in software associated with a digital telephone switch, such as a Harris switch, used in the cellular network for digitizing and transmitting multiplexed telephone signals over a T1 or other trunk line. Such switches operate on a digitized, pulse code modulated, time division multiplexed data stream in which each time slot carries a different call. It would be possible to perform the functions disclosed with reference to Figures 1 and 2 by monitoring the series of numbers passing through the T1 compatible switch, representing digitally sampled signal levels, and to similarly determine the frequency content of the signal in each call by examining the T1 trunk line's PCM signal level sample numbers in one or more successive time divisions associated with that call. A large concentration of similar numbers could be used to indicate a data call. Fourier transform algorithms could also be used to determine the frequency content of the signal based on the changes in signal level noted, and a data call could be identified by a large high-frequency level content in a manner similar to that described above.

One method for selecting a reference level for use with the process and apparatus discussed above is

depicted in Figure 3. Figure 3 shows a graph of channel power level versus frequency. The graph contains a typical power level curve for a channel containing a data transmission 302, a typical power level curve for a channel containing a voice transmission 304, and one possible reference level 306 that could be used. As discussed above, the reference level is selected based on empirical testing. The level is selected such that when a data transmission is present on the selected channel, the channel level 302 associated with that data transmission will be greater than the reference level 306. Similarly, when the selected channel is carrying a voice signal, the channel level 304 associated with the voice transmission will be lower than the reference level 306. As can be seen from Figure 3, there are a number of acceptable reference levels that could be used. In the most preferred embodiment of the invention, however, the reference level would lie approximately half-way between the typical output voltage of the rectifier and filter 206 (shown in Figure 2) for a data transmission and the typical output voltage of this rectifier and filter 206 for a voice transmission.

The data detector 202 may be installed at any desired location in a cellular radiotelephone system, for example at a cell site as shown in Figure 4. Figure 4 contains an antenna 402, cellular transceiver and demodulator circuitry 404, channel transmission lines 406, channel selection circuitry 408, channel analysis apparatus 202, cellular command network 410, and billing computer 412.

The antenna 402 is connected to the cellular transceiver and demodulator circuitry 404. Circuitry 404 is connected to the channel selection circuitry 408 through one or more channel transmission lines 406.

Channel selection circuitry 408 is connected to channel analysis apparatus 202, cellular command network 410, and billing computer 412. Channel analysis apparatus 202 is connected to cellular command network 410 and billing computer 412.

In operation, antenna 402 receives a radiotelephone transmission. The transmission is then processed by the cellular transceiver and demodulator circuitry 404. Circuitry 404 demodulates the radiotelephone transmission and produces a plurality of single cellular channel outputs. The output of circuitry 404 is connected to transmission lines 406 which carry the single cellular channels to channel selection circuitry 408. Preferably, a separate data detection circuit may be provided for each channel. However, if the data detection circuits are constructed such that a plurality of channels may be effectively monitored by a single channel analysis unit 202, channel selection circuitry 408 may be provided to select one of the cellular channels for analysis and provide that channel on output 409. The channel to be analyzed is provided to the channel analysis unit 202. Additionally, identification of the channel to be analyzed is provided to both the cellular command network 410 and the billing computer 412. This operation is desirable so that if the channel is found to contain a data transmission, the command network 410 and billing computer 412 will be able to determine which channel was analyzed and to take appropriate action. This may include raising or lowering the charges for that channel, or marking the channel for modified call processing. Alternatively, the command network 410 and billing computer 412 could determine the channel directly from the output of the channel analysis apparatus 202, e.g. based on the timing

of the monitoring operations of channel analysis apparatus 202.

The output 411 of the channel analysis apparatus 202 indicates whether that channel contains a data transmission. This output is connected to cellular command network 410 and billing computer 412. As described above, this allows these devices to handle the call differently if a data transmission is detected.

Figure 5 shows a flowchart of a second preferred embodiment of the present invention in which a special predetermined dialing sequence is generated by user equipment and detected by the cellular carrier equipment. Figure 5A shows a flowchart of a process that could be used in mobile cellular equipment for automatically inserting the predetermined dialing sequence into a number dialed by a user. Figure 5B shows a flowchart for a process that could be used at a cellular receiving site by a cellular carrier for detecting the predetermined dialing sequence. Although this dialing sequence may be automatically inserted during dialing by cellular equipment, it may also be manually inserted by a user desiring to make a cellular data call. In such a case, a user might append a * or # key, or another predetermined signal generated from the cellular telephone or an attached device. For example, such signals could include numeric or any other keypad generated signals depending on the capabilities of the keyboard or its circuitry. A standard DTMF keypad is capable of generating 16 different dialing signals, including the numerals 0-9, #, *, and four additional signals A, B, C, and D for which keys are not typically provided on landline telephones. Any of these signals, or combinations thereof, may be appended at the end of the dialed number to indicate to the cellular carrier that the call is a data call. The signals used

may be signals which can be generated by the cellular telephone keypad or may be other signals which cannot normally be generated by the keypad. A similar code imbedded in the dialed telephone number or preceding the dialed telephone number could also be used, depending on the convention established by the cellular carrier.

Typically, it is anticipated that the dialing signals used to identify the call to the cellular carrier as a data call will be generated by a cellular-capable computer modem of the type disclosed in U.S. Patent 5,127,041 or pending application Serial No. 07/863,568, the disclosures of which are incorporated by reference, or an interface associated with such a modem where applicable. In this case, the computer modem or its associated interface will generate the dialing signal instructions to the cellular radiotelephone being used to place the call, and these dialing signal instructions will include the required dialing sequences according to a convention established by the cellular carrier(s) to identify the call as a data call. The communications software of the computer associated with the computer modem can be provided with the telephone number to be dialed in a known manner, with such programming including in this case any additional dialing sequences required to identify the call as a data call. For example, if the telephone number of the call receiving party is 555-1234, and the cellular carrier recognizes the dialing sequence #* as indicating a data call, the "phone book" of the communications software can be programmed with the number 5551234#*.

In one particularly preferred embodiment, the correct telephone number to be dialed can be entered in the "phone book" of the communications software in the computer, such as "5551234", and the cellular-capable modem is designed to automatically add the required

additional dialing sequences to identify the call as a data call, but does so only when the modem is connected to a cellular telephone system. This avoids the potential need to change the programming of the computer communications software or to select a different "phone book" entry or scripted connection sequence depending on the type of telephone network being used (e.g. landline vs. cellular).

Thus, when such a modem is connected to a cellular telephone system, and a dialing instruction is received, the modem may add data call identifying dialing sequences, such as appending a "#*" sequence to a received number "5551234". When the modem is connected to a landline telephone system, the modem will not generate the additional appended dialing sequences since such signals are not necessary in landline communications. Of course, it would also be possible, although less preferred, to program the modem to automatically generate the additional signals for both landline and cellular communications since telephone company landline central offices normally ignore additional dialing sequences after a full telephone number is received. However, if the cellular carrier adopts a convention which involves additional dialing sequences that precede or are intermixed within the telephone number to be dialed, selective transmission of such dialing sequences with only cellular connections would be essential since such additional dialing sequences would interfere with normal landline call placement.

Referring now to Figure 5A, a flowchart of a process that may be used to insert a predetermined dialing sequence into a dialed number is shown. In block 502, the modem or its associated interface receives dialing instructions from the associated

computer. The receipt of these signals continues until it is determined that the dialing is complete. Dialing completion may be determined by a number of methods, including counting the number of digits dialed, failure to receive a further dialed digit within a predetermined time, or the receipt of an indication signal indicating that the full telephone number has been transmitted and that dialing should commence.

When the full telephone number is received, the modem or its interface operates in block 504 to insert the predetermined additional dialing sequence to identify the call to the cellular carrier as a data call. In the example given above, the dialing sequence "#*" would be appended to the telephone number received, e.g. 5551234 to form the full dialing sequence 5551234#*. This dialing request would then be transmitted as shown in block 505 through the cellular telephone by the modem or the interface, typically by transmitting signals to the cellular bus which cause the cellular telephone to emulate keypress signals from its own control keypad. The modem or the interface will then cause the cellular telephone to emulate the pressing of the "send" key to transmit the dialing sequence to the cellular carrier, thus completing the transmission of the modified dialing sequence.

While the predetermined dialing sequence has been described in terms of transmission during call setup, it would also be possible to transmit such dialing information over the command channel of the cellular system during the progress of a call or following the completion of a call. Signals could be transmitted periodically, if desired, during data transmission in a data call operation.

Figure 5B is a flowchart for a process useful at a cellular receiving site by a cellular carrier for

detecting the predetermined dialing sequence generated according to the process disclosed above with reference to Figure 5A. The cellular telephone network command system operates in block 508 to receive the cellular dialing request over a command channel from a cellular radiotelephone which is in communication with a cellsite connected to the command system. The receipt of this dialing sequence occurs in a conventional manner, except that the dialing sequence may selectively include information specifying that a data call is to be placed. In block 510, the command system examines the dialing sequence to determine whether this dialing sequence includes the predetermined signals indicating that a data call is being placed. If so, control passes to block 512 and the cellular command system will flag the call as a data call and process it accordingly. As described previously, various differential processing of data calls is possible as compared to voice calls, including differential rates used in billing, differential handoff operation, and differential channel assignment.

In a further embodiment illustrated in Figure 6, predetermined detectable information may be embedded in the data and sent over the "voice channel" of the cellular telephone system, where such information can be detected by monitoring. For example, in the data transfer protocol disclosed in U.S. Patent RE 34,034, the information is formed into packets and each packet is transmitted with associated packet identification and cyclic redundancy check information. The system could be designed to detect the packet identification or packet separation information. It would also be possible to add to any data stream to be transmitted over a cellular telephone any desired periodic predetermined bit pattern. For example, a pattern such

as 00FF00FF00FF (hexadecimal) could be transmitted after every N packets, where N is an integer. The modems used would in any case be programmed to eliminate such bit patterns upon receipt as being part of the protocol overhead, so that this operation would be transparent to those transmitting data. The repeating bit pattern provided in the protocol could be detected by demodulating the data stream at any point and monitoring the resulting data to identify the protocol in use. In this way, differential operation could be achieved depending not only upon the transmission of data, but upon the type of protocol used. More preferably, the signal pattern of the data stream can be monitored as the data stream passes through cellular telephone office switching equipment in digital time-division-multiplexed form.

In the embodiment of Figure 6, a cellular telephone system cell site is shown generally at 602. The cellsite includes antenna 604, cellsite transceiver 606, digital/analog converter 608, trunk switch 610, and command system circuits 612. Command system circuits 612 are connected appropriately to control the other system elements, and command system circuits 612 are also connected to the remainder of the cellular telephone system 614, which includes mobile switching offices, other cellsites, billing and recording equipment, landline telephone central office interfaces, and other parts of a conventional cellular telephone system. In operation, the conventional cellsite transceiver 606 transmits and receives calls and commands between the cellsite 602 and mobile users served by cellsite 602 over both voice and command channels, under the control of the command system 612. A large number of radio channels are provided at each cellsite 602 to support numerous mobile users within

range of cellsite 602. Typically, at least the voice channel information transmitted to and from these users over the radio channels is converted to a multiplexed digital form by analog/digital converter 608 which can then be processed on a standard telephonic trunk line 616, such as by trunk switch 610.

In the present invention, the trunk switch 610 is provided with special software, either operating within trunk switch 610 or in a connected computer (not shown). This software monitors the data stream over the trunk line 616 to identify patterns associated with data transmission rather than voice transmission. For example, the software may be programmed to recognize the passage of particular voltage patterns reflecting the transmission of a particular bit pattern, such as the 00FF00FF00FF pattern given as an example above. This pattern could be identified in the digital T1 transmission stream as a series of alternations between two substantially identical voltage levels, which would be reflected as a series of alternations between two substantially identical pulse code modulated codes. If such a pattern is recognized during the passage of one or more time divisions associated with a particular channel, it can be deduced that the channel is being used for data transmission. Confirmation of this deduction by more detailed analysis of the signal carried on the channel can be provided, if desired, in any of the manners described herein to avoid incorrect identification of data calls. If a channel is identified as carrying a data call by the trunk switch 610 or an associated computer monitoring system, the switch or computer can transmit a signal to the command system 612 or to other components of the cellular telephone system 614, such as a billing computer, to cause differential operation of the cellular telephone

system based on the presence of a data call rather than a voice call. Thus, a method for detecting the use of particular data protocols over a cellular telephone network has been disclosed.

Similarly, as discussed previously in conjunction with Figure 2, a bandwidth usage analysis can be performed if desired by the trunk switch 610 and its associated equipment. By monitoring the dispersion over a predetermined period of time of the digital numbers carried over each channel of trunk line 616, which represent the original analog signal levels, the system according to the present invention can discriminate between data signals and voice signals. This could be accomplished by counting the frequency of appearance of each possible digital number over a brief, defined time period. Then, the collected frequency data can be analyzed to discriminate between voice and data signals. For example, a voice signal will typically have periods of low or no signal level, and a broader variety of signal levels. A data signal can be identified by highly concentrated signal levels.

Also, data signals could be identified by maintaining either a count of the sample-to-sample magnitude changes, or a running average of the magnitude changes in the digitized representation of the signal. Larger and faster changes in the digitized signal levels can be used as an indicator of data transmission. A cutoff level of signal change magnitude usable to effectively discriminate between voice and data signals can be determined experimentally using methods similar to those described previously for determining the reference voltage V+ used in the discrete analog monitoring circuit of Figure 2.

The more abrupt voltage changes in a data signal are closely associated with the greater level of high-

frequency signal components present in the signal when data is transmitted. That is, more substantial high frequency components are required to produce a more abruptly changing signal.

Thus, a series of methods and mechanisms have been disclosed for effectively discriminating between data and voice signals transmitted over a channel of a cellular radiotelephone system. The methods disclosed also make it possible to vary the operation of the cellular radiotelephone system, including channel assignment, billing rates and methods, and handoff control based on the determination of current channel usage (voice or data).

I claim:

1. A method of controlling the operation of a cellular radiotelephone system, comprising the steps of:

providing data presence detection means for discriminating between voice signals and computer data exchange signals occurring in a call being transmitted over a specified cellular radiotelephone voice channel, said data presence detector having an output, said output providing a signal indication when said call contains computer data exchange signals;

operating the data presence detection means to selectively generate said signal indication at said output;

providing control means, connected to receive said output, for varying call handling operations of said cellular radiotelephone system in response to said signal indication when said call contains computer data exchange signals;

operating said control means to provide differential call handling operations for said call in said cellular radiotelephone system when said call contains computer data exchange signals.

2. An apparatus for controlling the operation of a cellular radiotelephone system, comprising:

a high pass filter connected to a radiotelephone circuit to be monitored and to a rectifier circuit, said highpass filter acting to produce a filtered AC signal containing frequencies above about 400 to 1600 hertz;

a rectifier circuit connected to said high pass filter and to a comparator, said rectifier circuit acting to rectify said filtered signal and produce a DC signal;

a comparator connected to said rectifier circuit and to a timer, said comparator acting to compare said

DC signal with a reference signal and to produce an indicating signal indicating whether said DC signal is above or below said reference signal; and

a timer connected to said comparator, said timer measuring the time that said indicating signal indicates said DC signal is above or below said reference signal and producing a second indicating signal indicating whether said DC signal is above or below said reference signal for about 4-10 seconds.

3. An apparatus for controlling the operation of a cellular radiotelephone system, comprising:

filtering means for filtering an input signal to produce a second signal having frequencies above about 400 to 1600 hertz, said filtering means connected to a radiotelephone circuit to be monitored;

integrating means connected to the filtering means for integrating second signal to produce a DC signal, said rectifier means connected to said filtering means and to comparison means;

comparison means for comparing said DC signal with a predetermined reference signal and providing an indication of whether said DC signal is above or below said reference signal, said comparison means connected to said rectifier means and to timer means;

timer means for timing the duration that said comparison means indicates said DC signal is above or below said reference signal and for providing a second indication if said DC signal is above or below said reference signal for about 4-10 seconds, said timer means connected to said comparison means and to processing means; and

processing means for processing said second indication signal, said processing means connect to said timer means.

4. An apparatus for controlling the operation of a cellular radiotelephone system, comprising:

detecting means for detecting a predetermined dialing sequence occurring during the placing of a cellular radiotelephone call, said detecting means connected to a cellular radio telephone network and to connecting means;

connecting means for connecting said detecting means to said processing means; and

processing means connected to said connecting means for processing said predetermined dialing sequence and altering the operation of said cellular radiotelephone system in response to said dialing sequence.

5. The apparatus of claim 4, in which the operation of the cellular radiotelephone system is altered to reduce the number of cell handoffs occurring in the monitored call.

6. The apparatus of claim 4, in which the operation of the cellular radiotelephone system is altered to change the billing rate charged for use of the system.

7. The apparatus of claim 4 in which the operation of the cellular radiotelephone system is altered so that the system selects a cellular channel having improved transmission properties.

8. A method of controlling the operation of a cellular radiotelephone system, comprising the steps of:

detecting a predetermined data pattern occurring in an information transmission, said data pattern indicating that the call contains a data transmission; and

invoking modified call-handling procedures in response to said determination that said cellular call contains a data transmission.

9. A method of controlling the operation of a cellular radiotelephone system, comprising the steps of:

detecting an analog signal present within a cellular channel, said analog signal indicating that the call contains a data transmission; and

invoking modified call-handling procedures in response to said determination that said cellular call contains a data transmission.

10. A method of controlling the operation of a cellular radiotelephone system, comprising the steps of:

detecting a predetermined dialing sequence occurring during the placing of a cellular radiotelephone call, said predetermined dial sequence indicating that the call contains a data transmission; and

invoking modified call-handling procedures in response to said determination that said cellular call contains a data transmission.

FIG. 1A

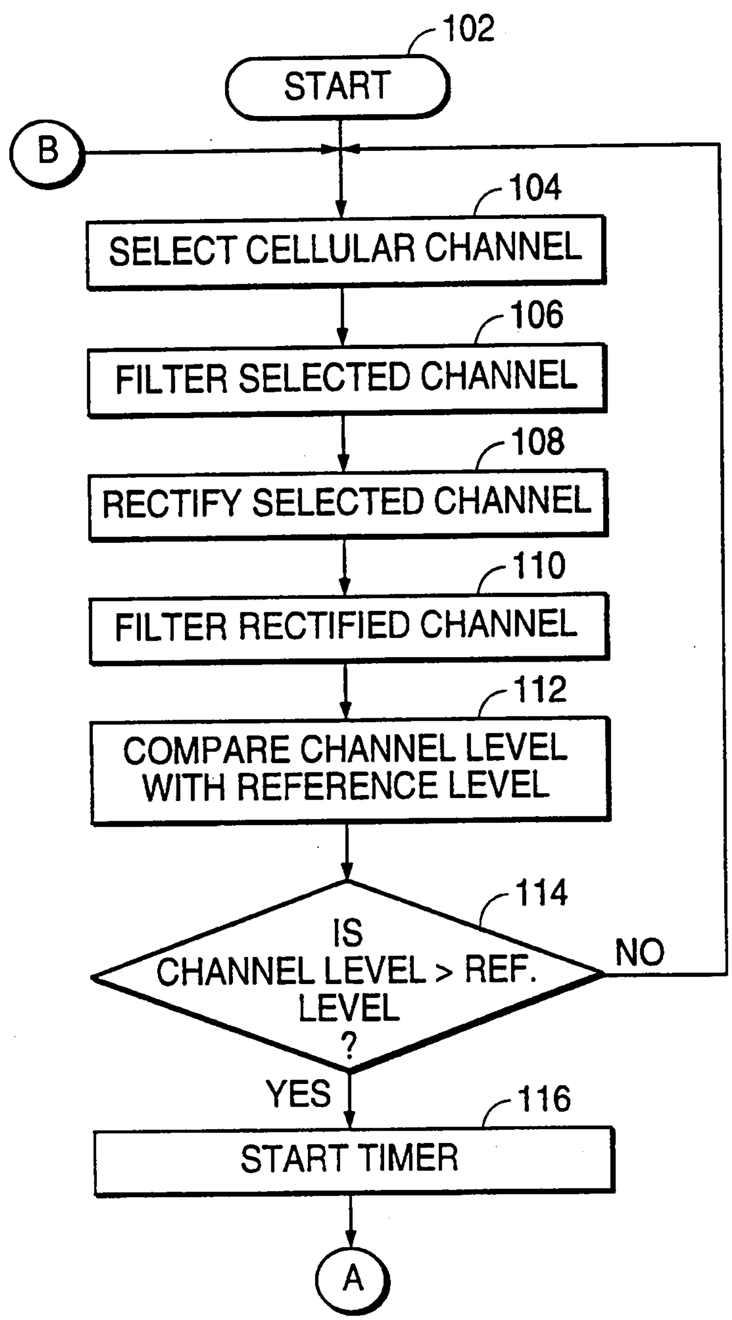

102
START
B
104
SELECT CELLULAR CHANNEL
106
FILTER SELECTED CHANNEL
108
RECTIFY SELECTED CHANNEL
110
FILTER RECTIFIED CHANNEL
112
COMPARE CHANNEL LEVEL WITH REFERENCE LEVEL
114
IS CHANNEL LEVEL > REF. LEVEL ?
NO
YES
116
START TIMER
A

FIG. 1B

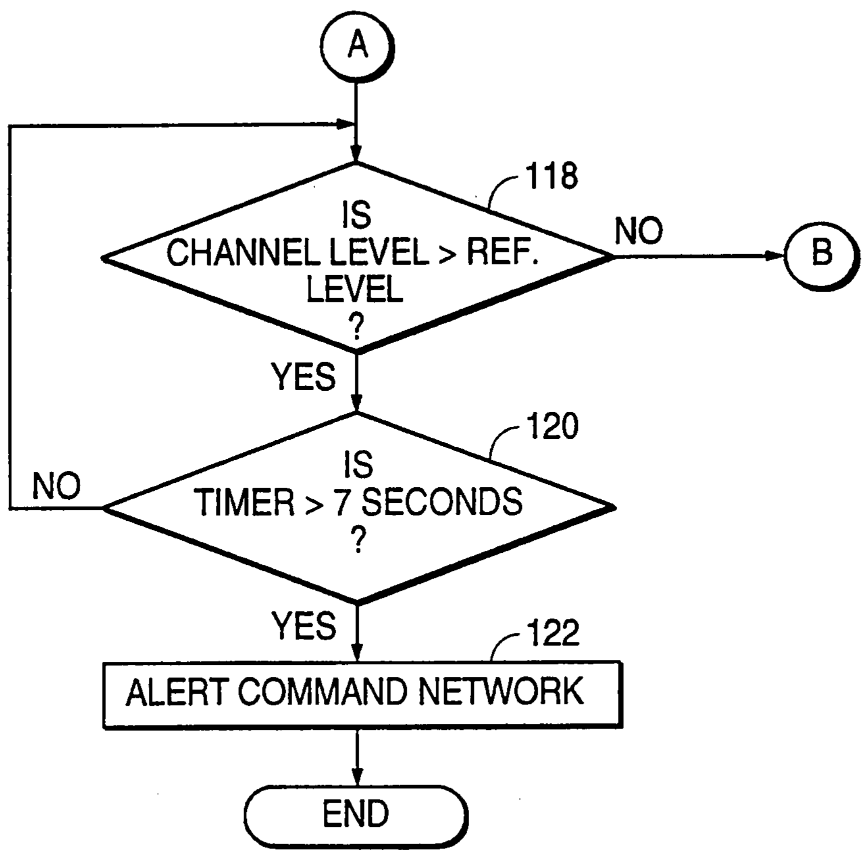

A
118
IS
CHANNEL LEVEL > REF.
LEVEL
?
NO
B
YES
120
IS
TIMER > 7 SECONDS
?
NO
YES
122
ALERT COMMAND NETWORK
END

FIG. 2

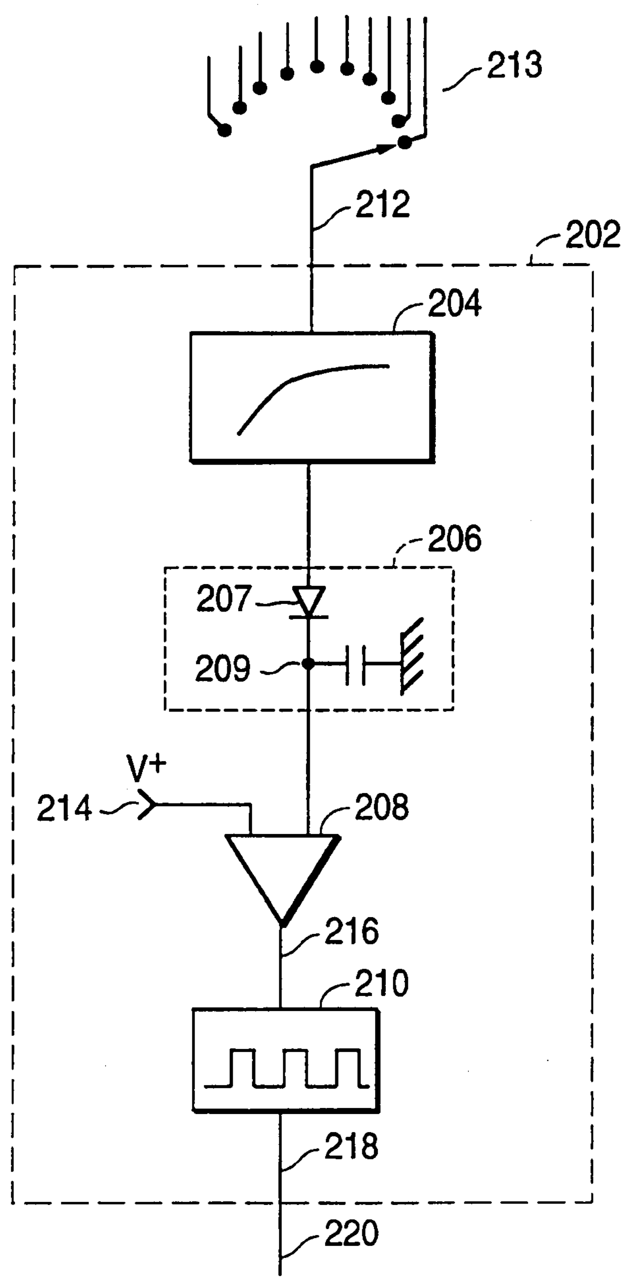


FIG. 3

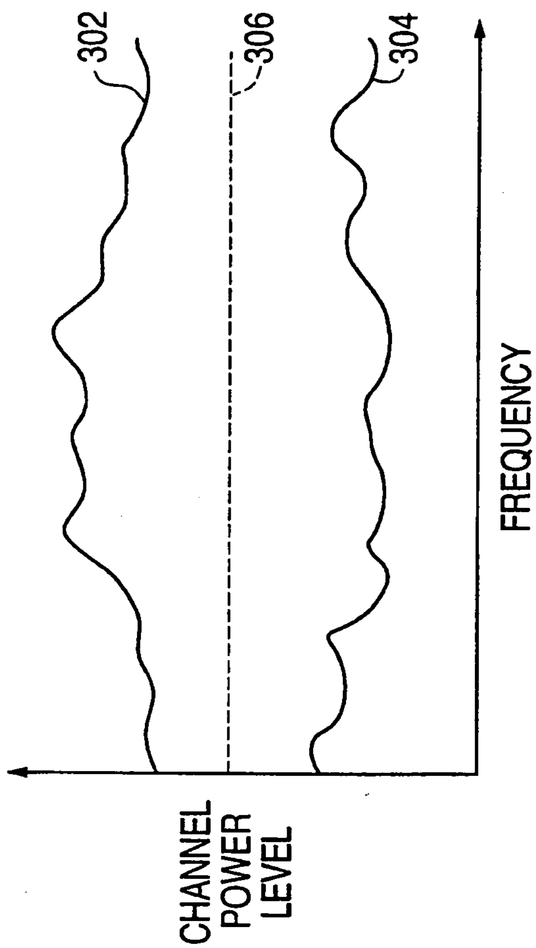


FIG. 4

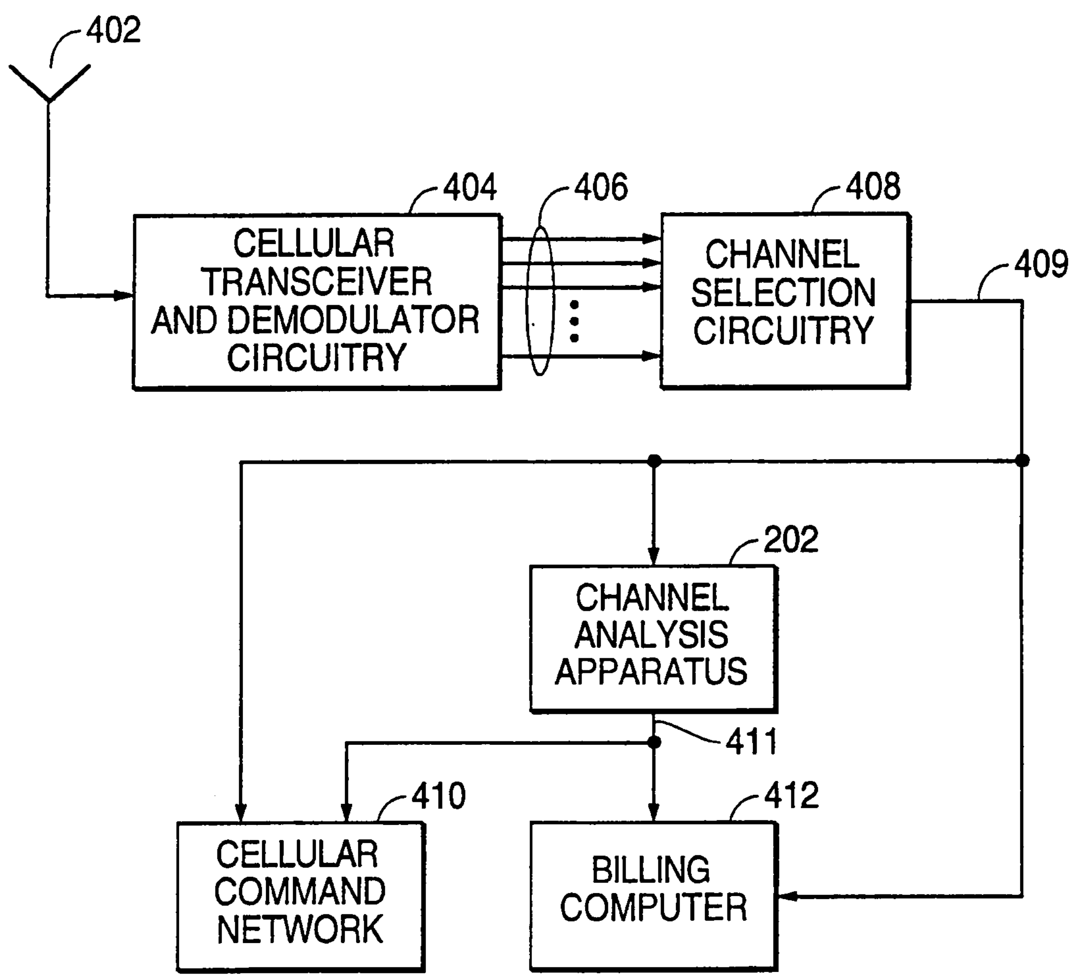

402
404
CELLULAR TRANSCEIVER AND DEMODULATOR CIRCUITRY
406
408
CHANNEL SELECTION CIRCUITRY
409
202
CHANNEL ANALYSIS APPARATUS
411
410
CELLULAR COMMAND NETWORK
412
BILLING COMPUTER

FIG. 5A

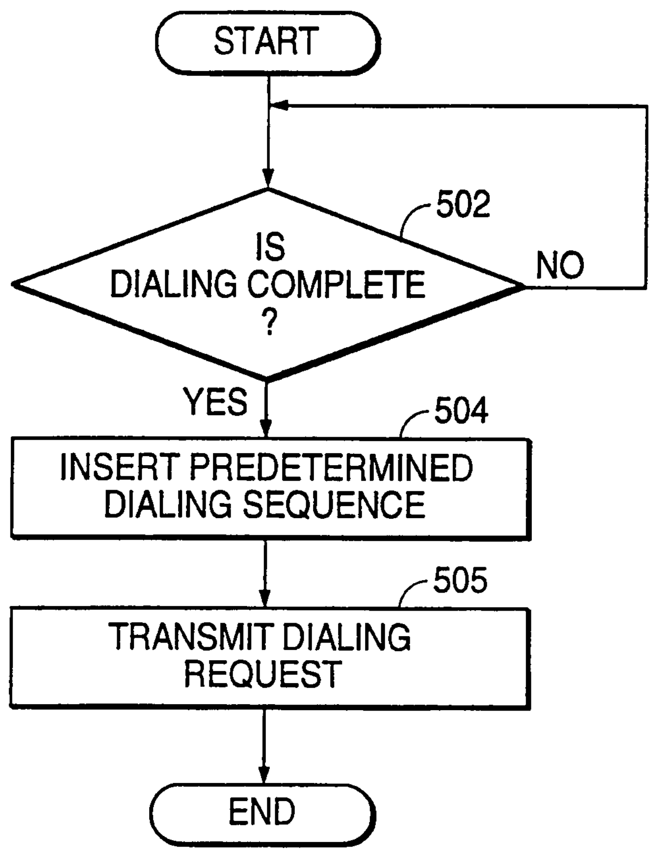

START
502
IS
DIALING COMPLETE
?
NO
YES
504
INSERT PREDETERMINED
DIALING SEQUENCE
505
TRANSMIT DIALING
REQUEST
END

FIG. 5B

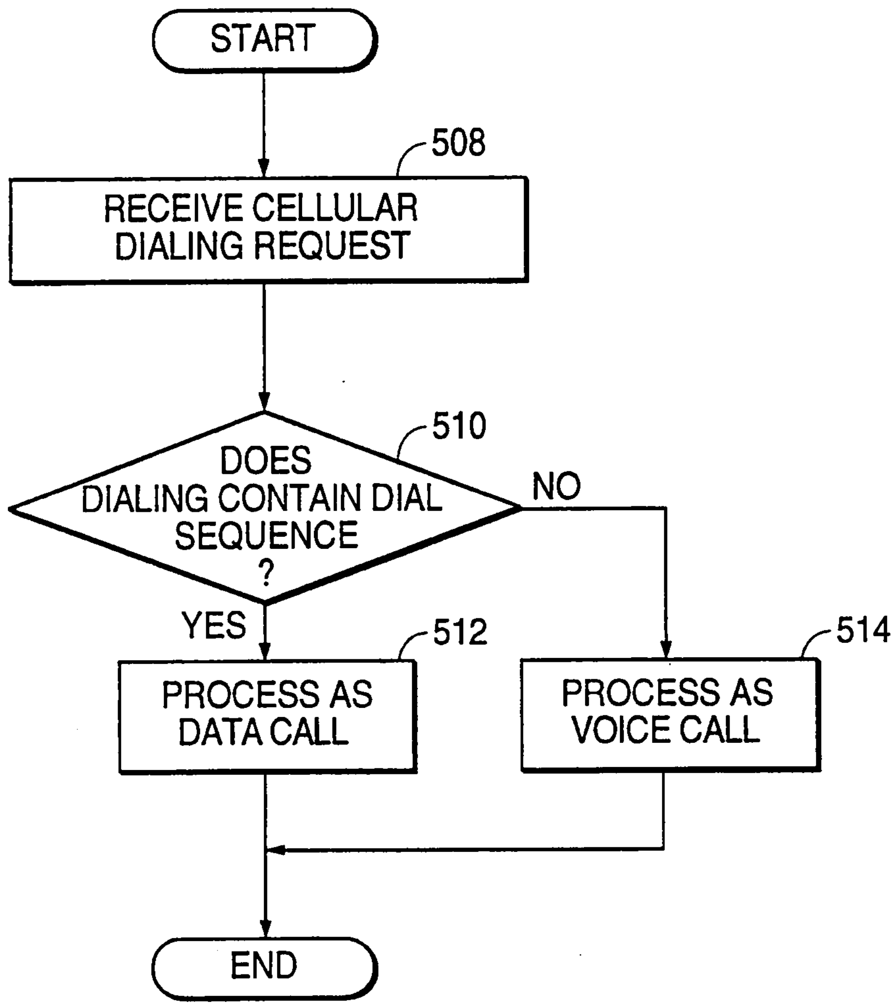
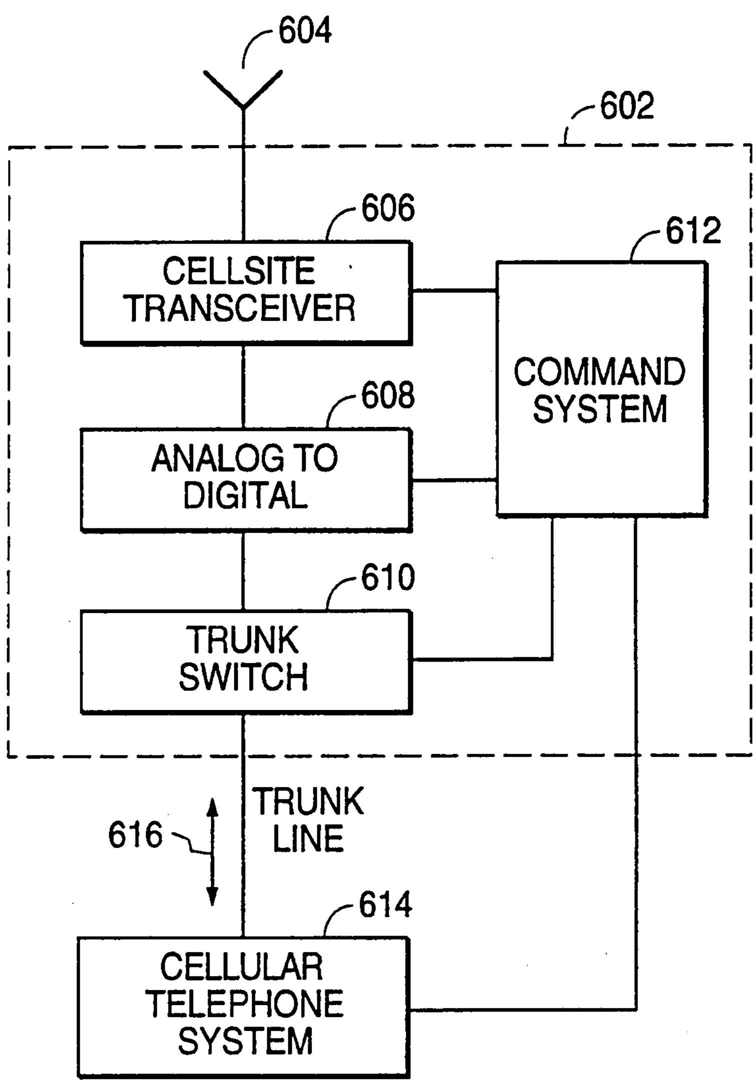

START
508
RECEIVE CELLULAR DIALING REQUEST
510
DOES DIALING CONTAIN DIAL SEQUENCE ?
NO
YES
512
PROCESS AS DATA CALL
514
PROCESS AS VOICE CALL
END

FIG. 6


604
602
606
CELLSITE TRANSCEIVER
612
COMMAND SYSTEM
608
ANALOG TO DIGITAL
610
TRUNK SWITCH
616
TRUNK LINE
614
CELLULAR TELEPHONE SYSTEM

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01199

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :H04M 11/00
US CL : 379/59
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/59, 56, 58, 62, 188; 340/826

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,654,867 (LABEDZ et al) 31 March 1987, figure 9c.	5
A	US, A, 4,697,281 (O'SULLIVAN) 29 September 1987	1-10
A	US, A, 4,972,457 (O'SULLIVAN) 20 November 1990	1-10
X ----- Y	US, A, 4,991,197 (MORRIS) 05 February 1991, figures 1 and 2, #62, 32, 54, 56 and column 7, line 62 to column 8, line 33.	1,4,8,10 ---------- 5-7
Y	US, A, 5,025,254 (HESS) 18 June 1991, abstract, figure 1.	7
X	US, A, 5,046,082 (ZICKER et al) 03 September 1991, figures 1B and 6, #606, 616, 800.	1, 8, 9

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 APRIL 1994	JUN 15 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer CURTIS KUNTZ
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4750

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01199

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5,127,041 (O'SULLIVAN) 30 June 1992	1-10
A, P	US, A, 5,249,218 (SAINTON) 28 September 1993	1-10

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS
Search terms: radiotelephone, mobile telephone, cellular phone, wireless telephone, billing, voice call, data call, radio telephone, mobile telephone system, control, voice signals, voice channel, cordless telephone, computer.